

Bridges Design Diploma

By EngoSoft training center

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Road way width & Super Elevation

Derive $h = \frac{Bv^2}{gR}$

$\phi_1 = \phi_2$

$\tan \phi_1 = \tan \phi_2$

$\frac{h}{B} = \frac{P}{W}$

$\cancel{B} \times \frac{h}{\cancel{B}} = \frac{v^2}{gR} \times B$

$h = \frac{v^2}{gR} \times B$

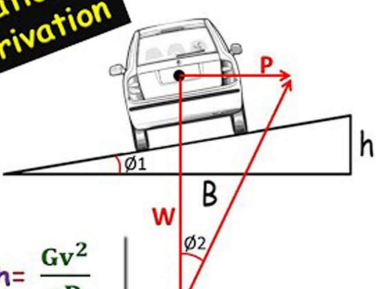
$\frac{P}{W} = \frac{v^2}{gR}$

$\tan \phi = \frac{\text{per base}}{\text{rise Run}}$

Super elevation's formula derivation

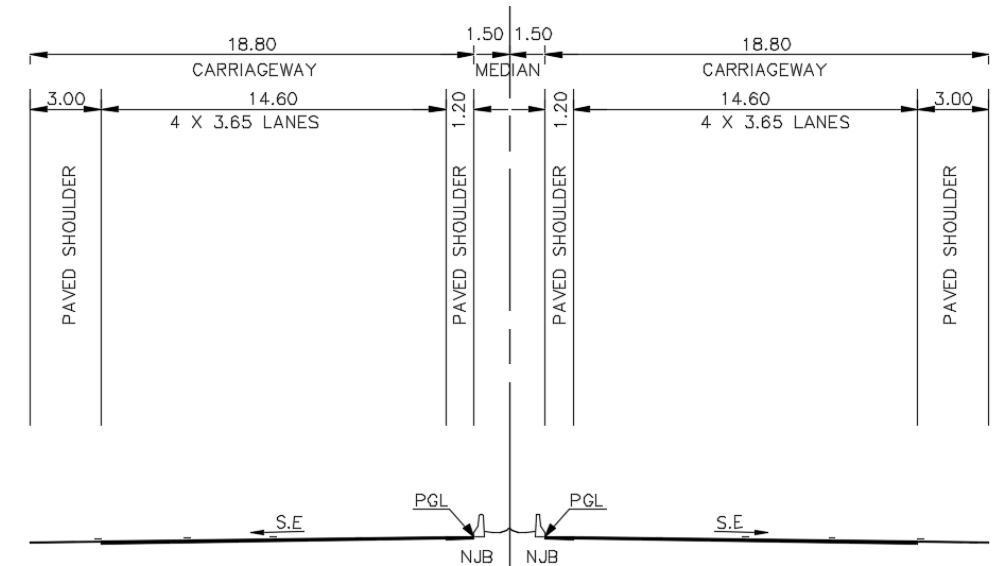
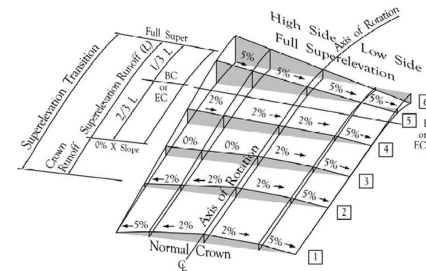
$h = \frac{Bv^2}{gR}$

$h = \frac{Gv^2}{gR}$





Super-elevation Transition

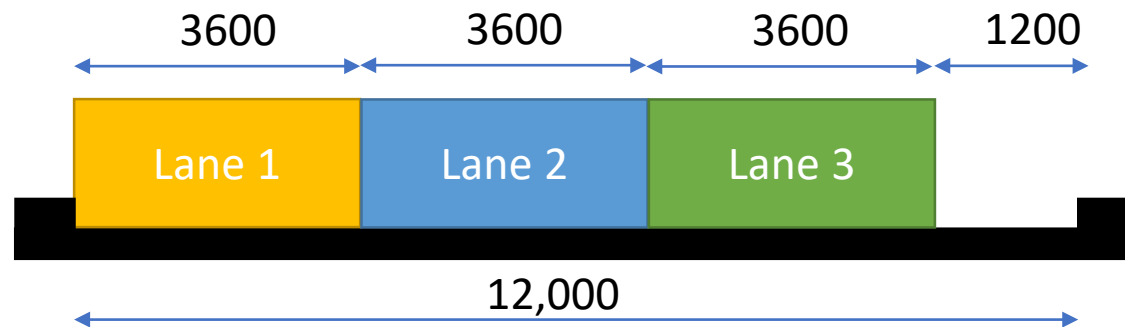


Number of design lanes

- Generally, the number of design lanes should be determined by taking the integer part of the ratio $w/3600$,
- where w is the clear roadway width in mm between curbs and/or barriers.
- Possible future changes in the physical or functional clear roadway width of the bridge should be considered.
- In cases where the traffic lanes are less than 3600 mm wide, the number of design lanes shall be equal to the number of traffic lanes, and the width of the design lane shall be taken as the width of the traffic lane.

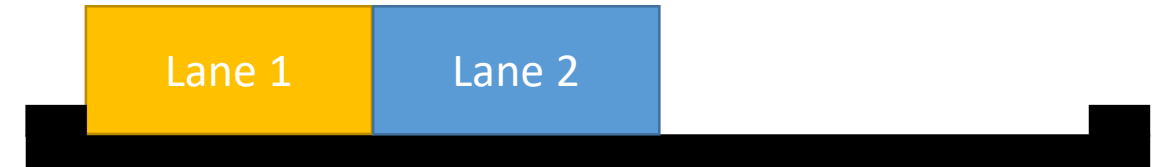
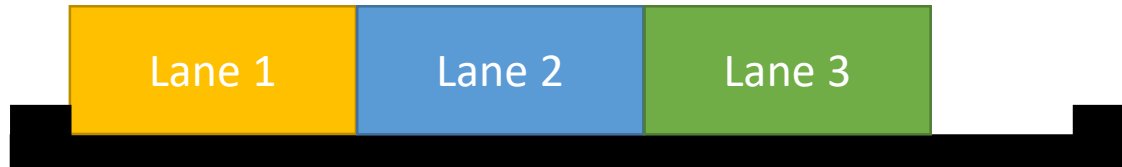
Number of design lanes

- Roadway widths from 6000 to 7200 mm shall have two design lanes, each equal to one-half the roadway width.
- Assume bridge width = 12,000 mm
- Number of lanes = $12000/3600 = 3.33$ (number of lanes 3)



Number of design lanes

- The extreme live load force effect shall be determined by considering each possible combination of number of loaded lanes account for the probability of simultaneous lane occupation



Multiple Presence of Live Load

- The equations are based on evaluation of several combinations of loaded lanes with their appropriate multiple presence factors and are intended to account for the worst case scenario.

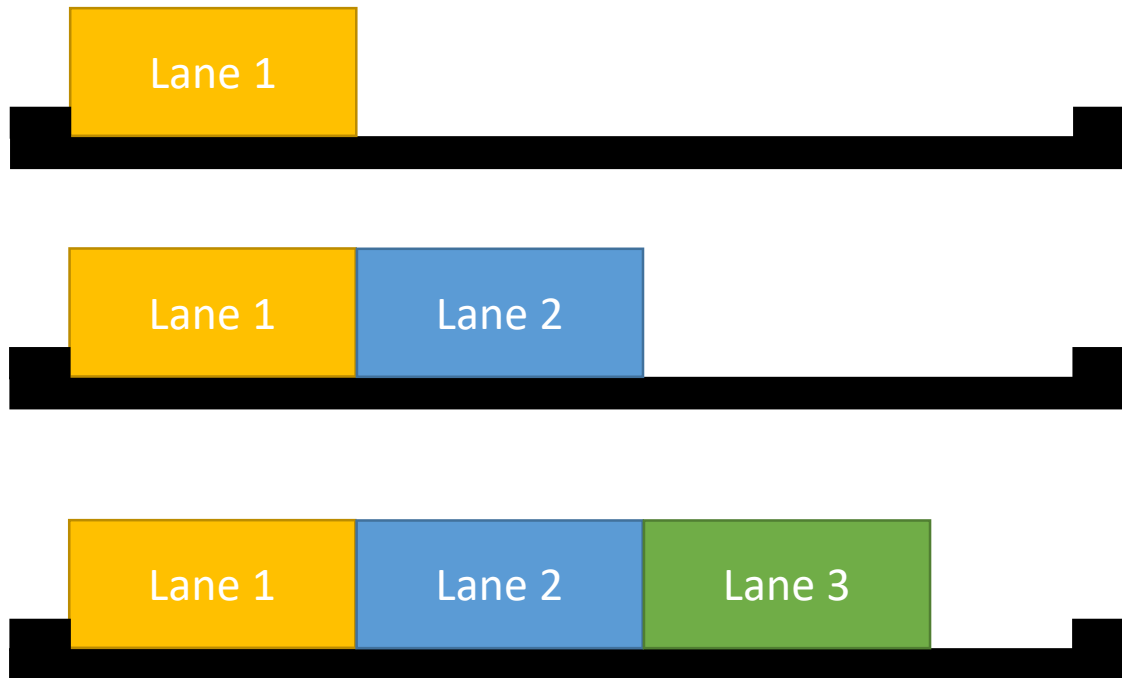


Table 3.6.1.1.2-1—Multiple Presence Factors, m

Number of Loaded Lanes	Multiple Presence Factors, m
1	1.20
2	1.00
3	0.85
>3	0.65

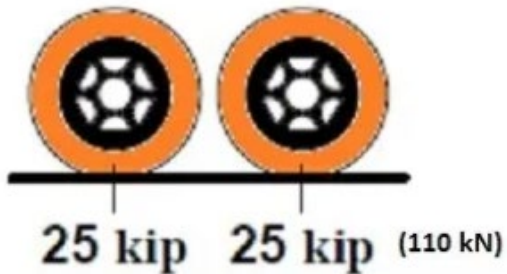
The entry greater than 1.0 in Table 3.6.1.1.2-1 results from statistical calibration of these Specifications on the basis of pairs of vehicles instead of a single vehicle. Therefore, when a single vehicle is on the bridge, it can be heavier than each one of a pair of vehicles and still have the same probability of occurrence.

Live Load As Per AASHTO LRFD

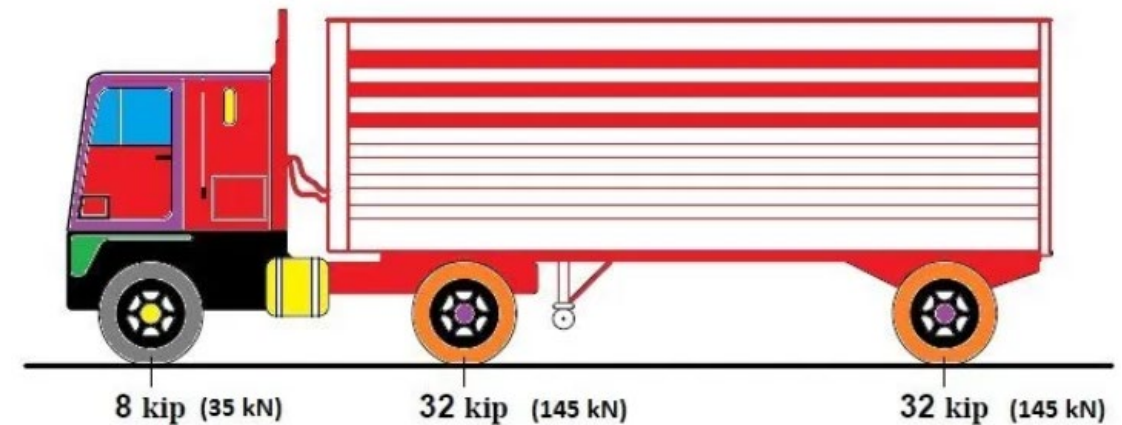
AASHTO LRFD Design Vehicular Live Load

Generally

- Vehicular live loading on the roadways of bridges or incidental structures, designated HL-93, shall consist of a combination of the:
 - Design truck or design tandem, and
 - Design lane load.



HL-93 Design Tandem AASHTO

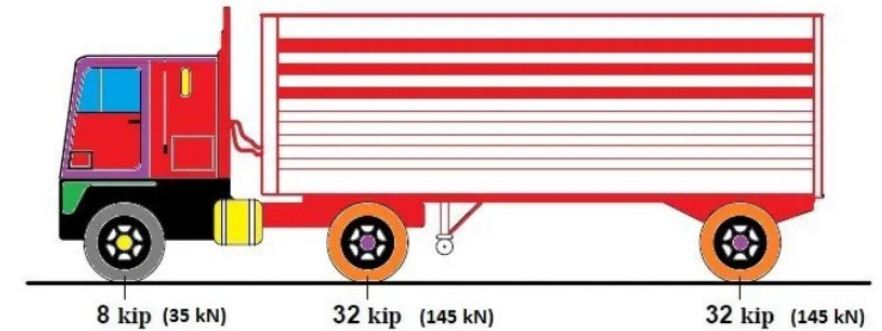


HL-93 Design Truck AASHTO

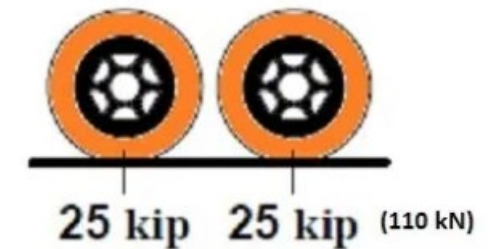
AASHTO LRFD Design Vehicular Live Load

HL-93 AASHTO Vehicular Live Loading (HL-93)

- HL-93 is a type of theoretical vehicular loading proposed by AASHTO in 1993. It is used as the design loading for highway structures in USA and other countries where AASHTO code is followed.
- Design truck
- Design tandem.



HL-93 Design Truck AASHTO

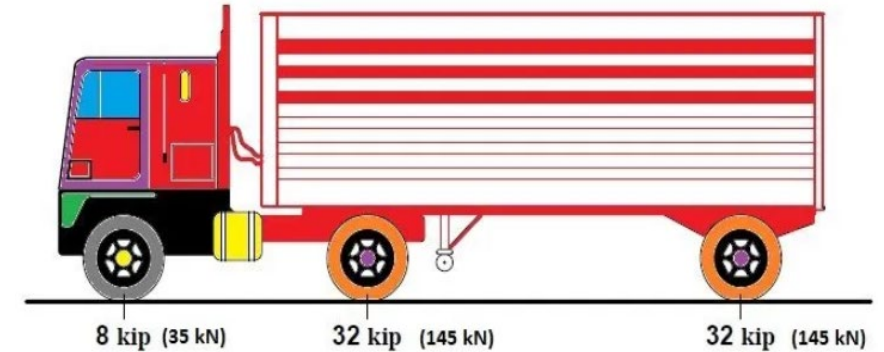


HL-93 Design Tandem AASHTO

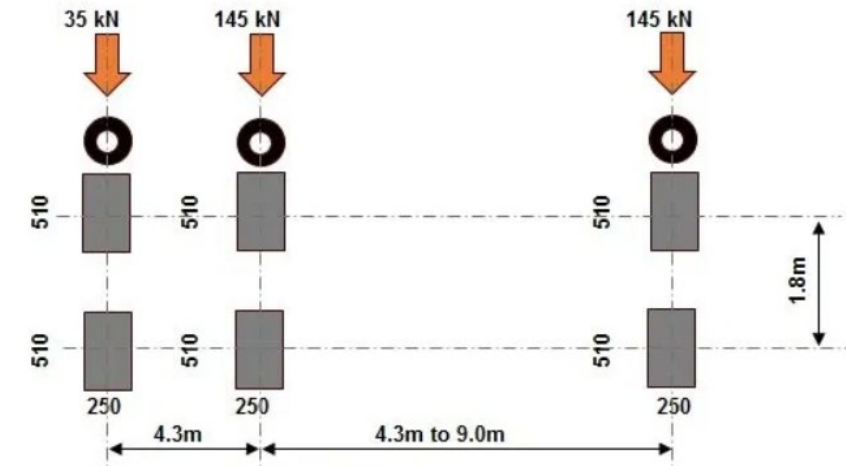
AASHTO LRFD Design Vehicular Live Load

Design Truck (HL-93)

- Design Truck consists of three axles,
- front and two rear axles with front axle weighing 8kip (35 kN)
- and two rear axles weighing 32kip (145 kN).
- The distance between front and rear axle is 14' (4.3m)
- and that of two rear axles can be varied between 14' (4.3m) to 30' (9.0m) to obtain the worst design force.
- The tire to tire distance in any axle is 6' (1.8m).



HL-93 Design Truck AASHTO



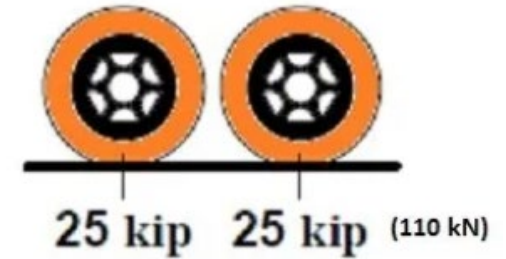
AASHTO HL-93 Truck Tire Plan

AASHTO HL-93 Truck Tire Plan

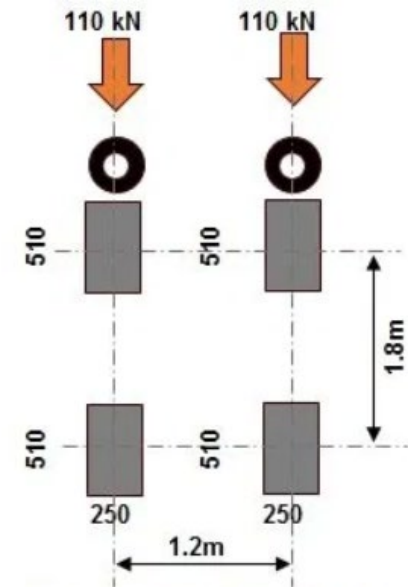
AASHTO LRFD Design Vehicular Live Load

Design Tandem (HL-93)

- HL-93 Design Tandem consist of twin axles spaced 4' (1.2m) apart,
- weight of each axle is 25kip (110 kN).
- The distance between the tires in an axle is 6' (1.8m).
- A dynamic load allowance shall be considered in both design truck and design tandem.



HL-93 Design Tandem AASHTO

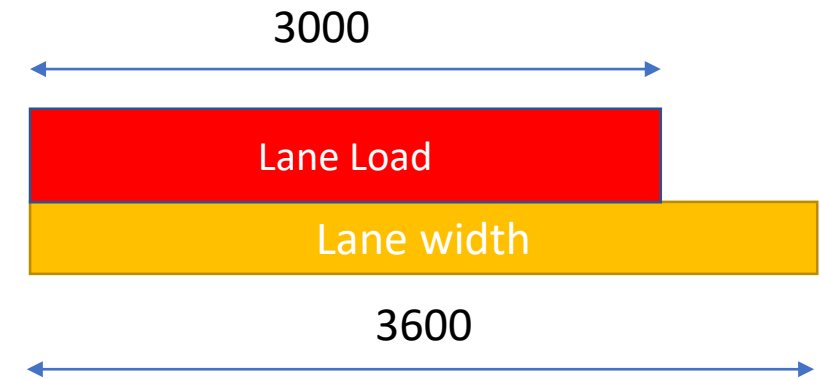


AASHTO HL-93 Tandem Tire Plan

AASHTO HL-93 Tandem Tire Plan

Design Lane Load

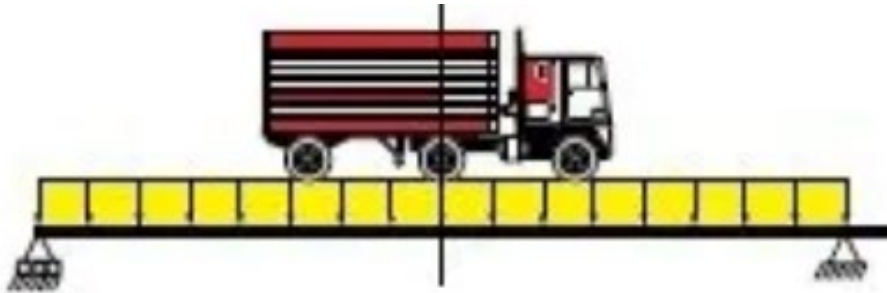
- The design lane load shall consist of a load of 0.64 klf (9.3 kN/m) uniformly distributed in the longitudinal direction.
- In transverse direction, the design lane load shall be assumed to be uniformly distributed over a 10.0' (3m) width.
- The force effects from the design lane load shall **NOT** be subject to a dynamic load allowance.



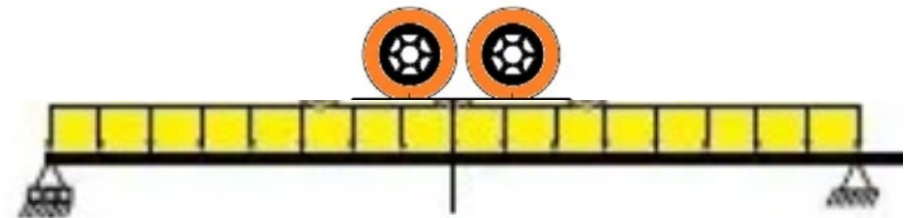
AASHTO LRFD Design Vehicular Live Load

Application of Design Vehicular Live Loads

- the extreme force effect shall be taken as the larger of the following:
 - The effect of the design tandem combined with the effect of the design lane load, or
 - The effect of one design truck with the variable axle spacing combined with the effect of the design lane load



Design Truck combined with design lane load

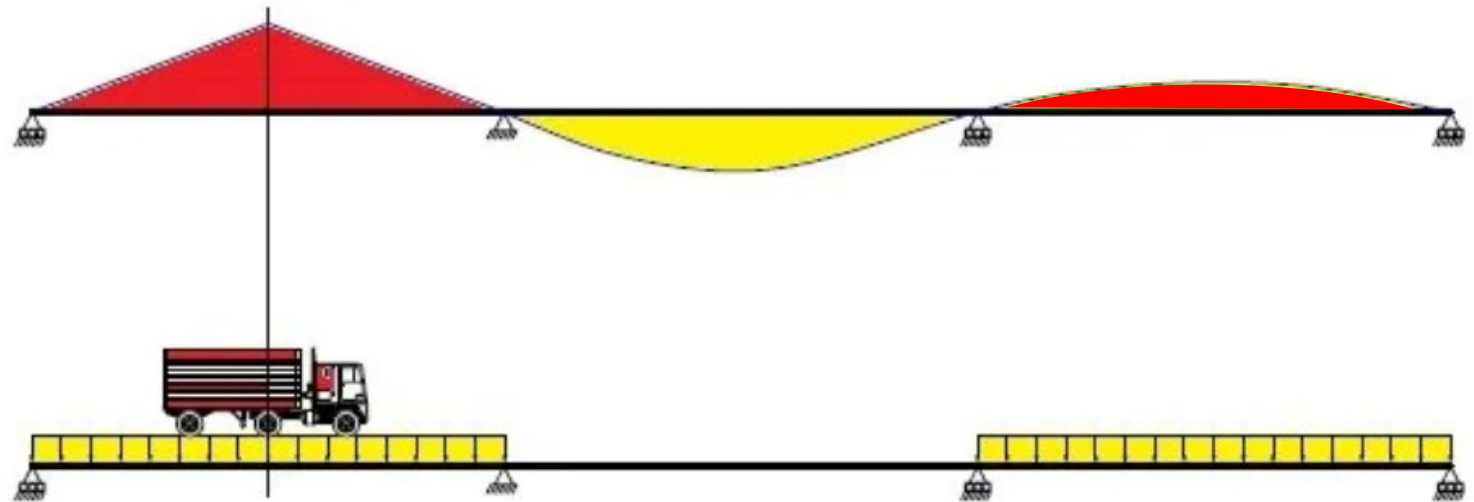


Design Tandem combined with design lane load

AASHTO LRFD Design Vehicular Live Load

Placement of HL93 Load & lane Load

- Design vehicle and lane loads should be applied in such a way that extreme force effect is obtained for design.
- In case of multiple lanes, Multiple Lane factors described in the code shall be considered.

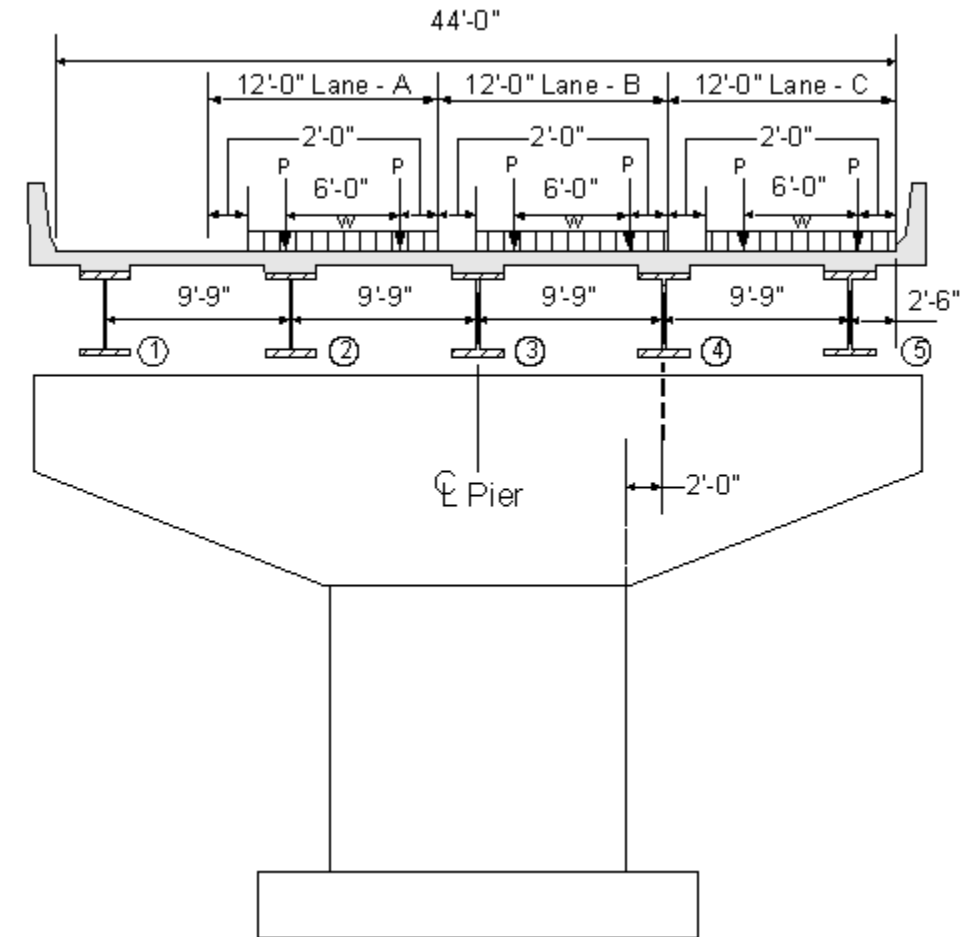


HL93 Truck Position for Maximum Sagging Moment in Span 1

AASHTO LRFD Design Vehicular Live Load

Generally

- each design lane under consideration shall be occupied by either the
- Design truck or Tandem,
- COINCIDENT with the lane load, where applicable.
- The loads shall be assumed to occupy 3000 mm transversely within a design lane.

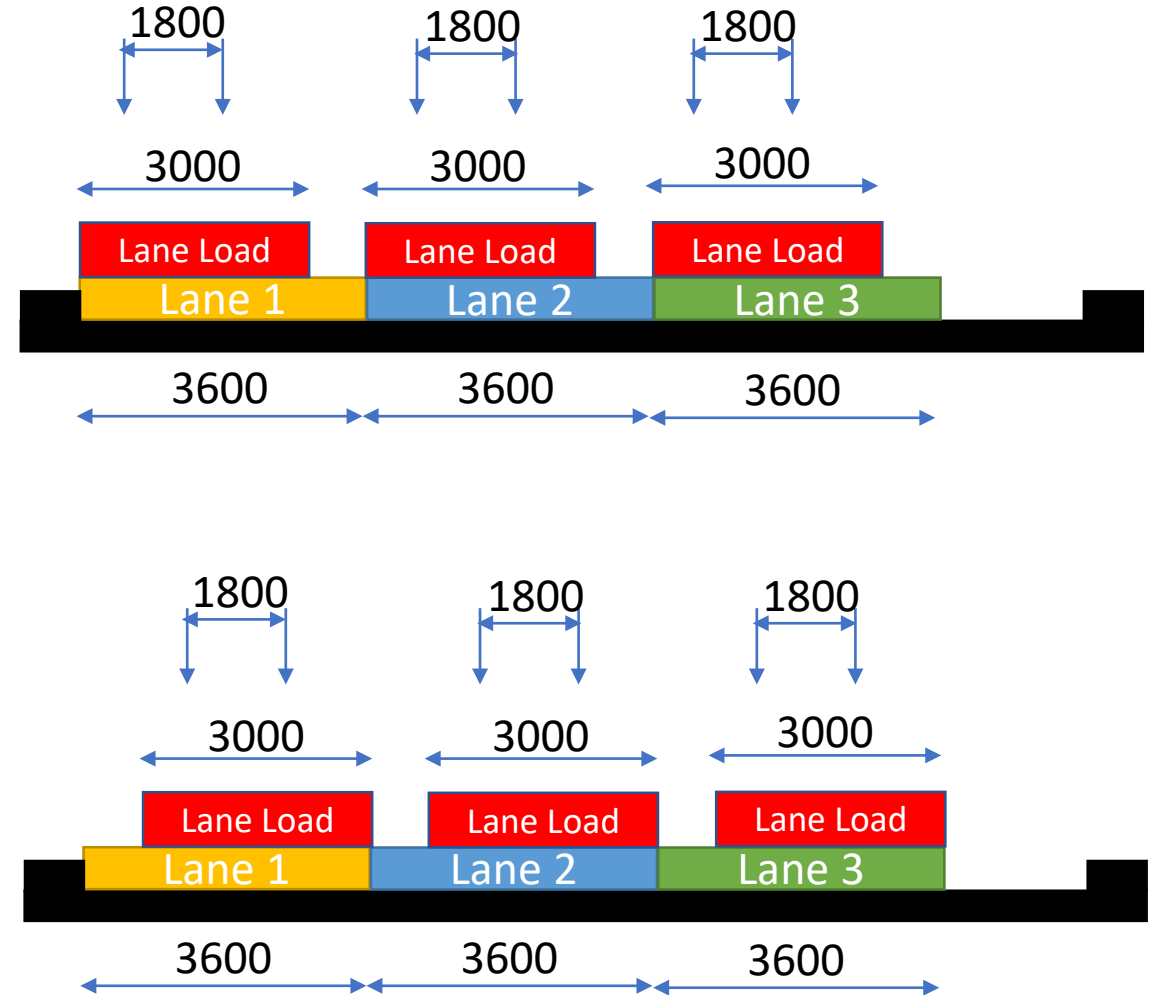
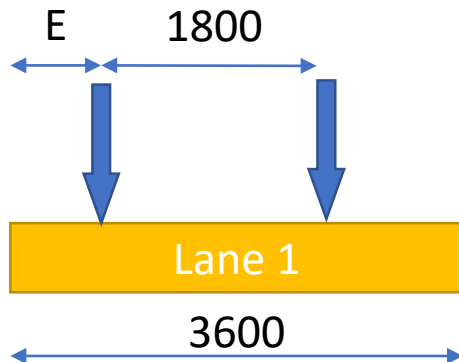


AASHTO LRFD Design Vehicular Live Load



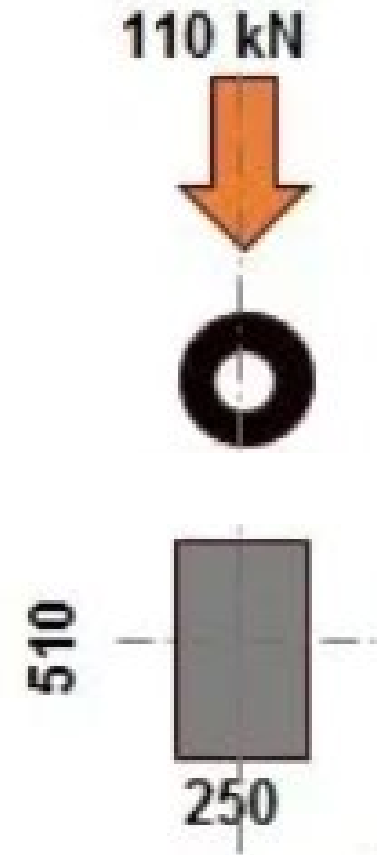
Generally

- Center of truck or tandem wheels must be at least (distance E in below shape)
- 2' (600mm) from the edge of a design lane
- 1' (300mm) from the deck overhang (cantilever).



Tire Contact Area

- For Truck and Tandem, the design contact area of tire is assumed to be a single rectangle of
 - Width 20" (510mm) and
 - Length 10" (250mm).
 - The tire pressure is assumed to be uniform over the contact area.



Tire contact area

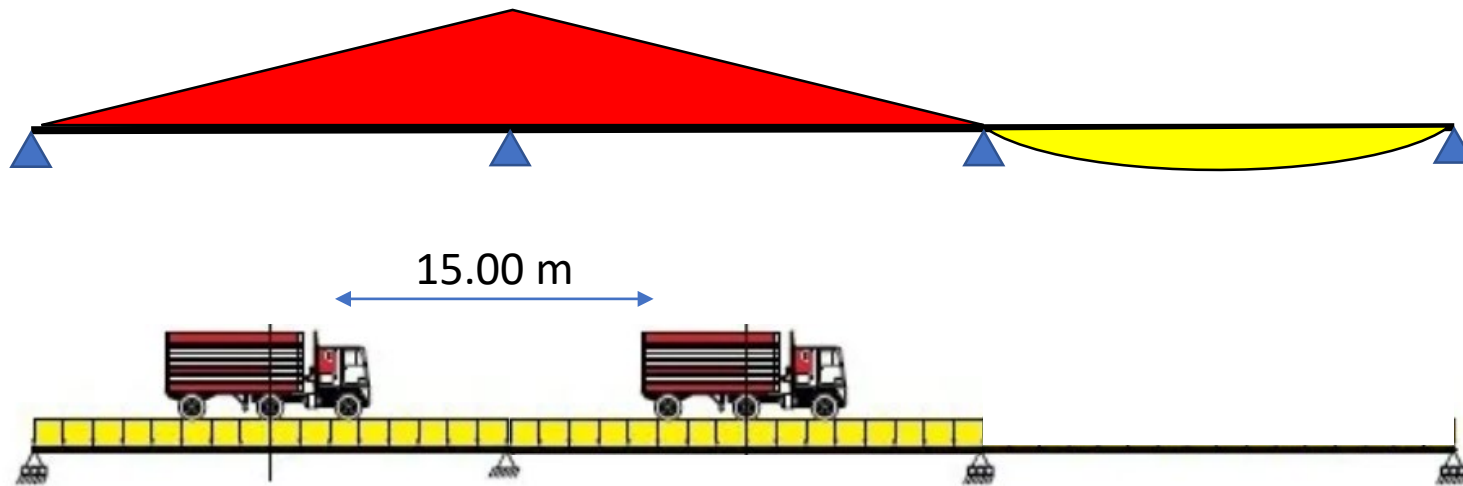
Negative Moment & Reaction at Interior Support

- For negative moment between points of contraflexure under a uniform load on all spans,
- and reaction at interior piers **ONLY**
 - 90% of the effect of **TWO** design trucks spaced a minimum of 50.0 ft (15.00m) between the lead axle of one truck and the rear axle of the other truck,
 - combined with 90% of the effect of the design lane load.
 - The distance between the 32.0-kip axles of each truck shall be taken as 14.0 ft (4300 mm).
 - The two design trucks shall be placed in adjacent spans to produce maximum force effects.

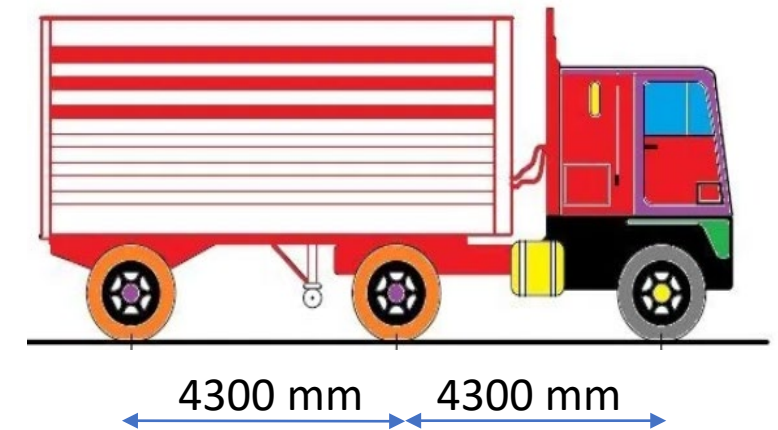
AASHTO LRFD Design Vehicular Live Load

Negative Moment & Reaction at Interior Support

- For negative moment between points of contraflexure under a uniform load on all spans,
- and reaction at interior piers **ONLY**



Position of trucks for negative moment and interior reaction



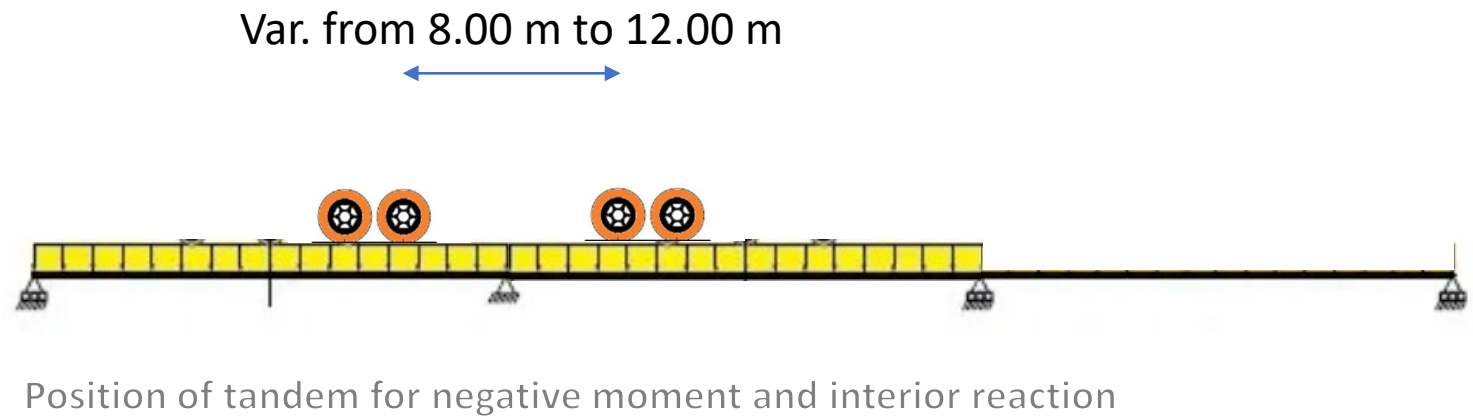
Truck for negative moment and interior reaction

Negative Moment & Reaction at Interior Support

- For negative moment between points of contraflexure under a uniform load on all spans,
- and reaction at interior piers ONLY
 - A pairs of the design tandem spaced from 26.0 ft (8.00m) to 40.0 ft (12.00m) apart, combined with the design lane load.
 - The design tandems should be placed in adjacent spans to produce maximum force effect.
 - One 100% of the combined effect of the design tandems and the design lane load should be used.

Negative Moment & Reaction at Interior Support

- For negative moment between points of contraflexure under a uniform load on all spans,
- and reaction at interior piers **ONLY**



AASHTO LRFD Design Vehicular Live Load



Dynamic Load Allowance (Impact)

- The static effects of the design TRUCK or TANDDEM, other than centrifugal and braking forces, shall be increased by a percentage for dynamic load allowance.
- The factor to be applied to the static load shall be taken as: $(1 + IM/100)$.
- The dynamic load allowance shall NOT be applied to pedestrian loads or to the design lane load.
- Dynamic load allowance need NOT be applied to:
 - Retaining walls not subject to vertical reactions
 - Foundation components that are entirely below ground level.

Table 3.6.2.1-1—Dynamic Load Allowance, *IM*

Component	IM
Deck Joints—All Limit States	75%
All Other Components:	
• Fatigue and Fracture Limit State	15%
• All Other Limit States	33%

Dynamic Load Allowance (Impact)

- The dynamic load allowance for culverts and other buried structures in percent shall be taken as:
 - $IM = 33 (1.0 - 4.1 \times 10^{-4} DE) \geq 0\%$

where:

DE = the minimum depth of earth cover above the structure (mm)

Centrifugal Forces: CE

- For the purpose of computing the radial force or the overturning effect on wheel loads, the centrifugal effect on live load shall be taken as the product of the axle weights of the design truck or tandem and the factor C;

- $$C = f \frac{v^2}{gR}$$

- Where,

v = highway design speed (m/s)

f = 4/3 for load combinations other than fatigue
and 1.0 for fatigue

g = gravitational acceleration: 9.807 (m/s²)

R = radius of curvature of traffic lane (m)

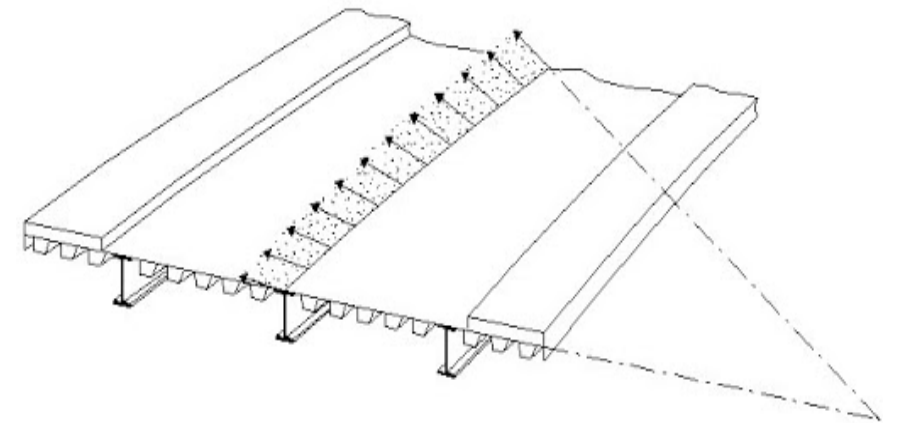
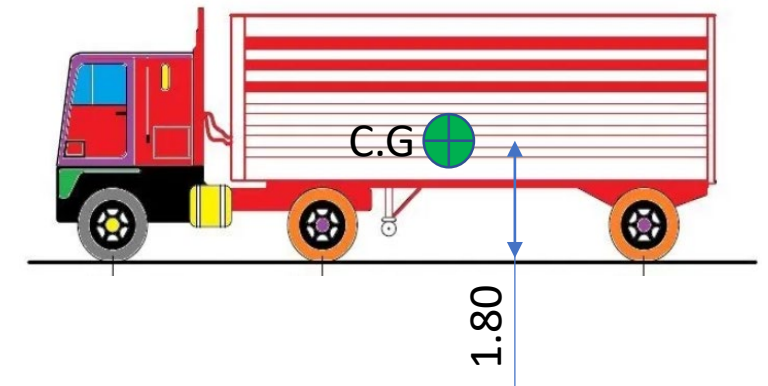


Figure 9 Centrifugal forces on curved bridges

Centrifugal Forces: CE

- The multiple presence factors shall apply.
- Centrifugal forces shall be applied horizontally at a distance 6.0 ft (1.80m) above the roadway surface.
- A load path to carry the radial force to the substructure shall be provided.
- Centrifugal force is **NOT** required to be applied to the **design lane load**, as the spacing of vehicles at high speed is assumed to be large, resulting in a low density of vehicles following and/or preceding the design truck.



Truck Center of Gravity Height

Braking Force: BR

- The braking force shall be taken as the greater of:
 - 25 percent of the axle weights of the design truck or design tandem or,
 - Five percent of the design truck plus lane load or five percent of the design tandem plus lane load.
- All design lanes shall be simultaneously loaded for bridges likely to become one-directional in the future.
- These forces shall be assumed to act horizontally at a distance of 6.0 ft (1.8m) above the roadway surface in either longitudinal direction to cause extreme force effects.
- The multiple presence factors shall apply.

Braking Force: BR

- **Example:**
 - **Bridge of width 12.00 m and length of 240 m, calculate the braking load:**

Number of lanes = $12.00 / 3.6 = 3.33$ (number of lanes = 3)

Multiple presence factor = 0.85 (for three lanes)

braking load is the larger of :

- $0.25 (3 * 0.85 * 325) / 240 = 0.863 \text{ kN/m.}$
- $0.05 (3 * 0.85 * 325) / 240 + 0.05 * (3 * 0.85 * 9.3) = 1.358 \text{ kN/m. (govern)}$

Live Load As Per Other codes

Design Vehicular Live Load as per other codes

Saudi Arabia:

- The MOMRA code of Kingdom of Saudi Arabia Double the AASHTO LRDF Vehicle Loads.

3. Design Tandem

The design tandem shall consist of a pair of 250 kN axles spaced 1.2 m apart. The transverse spacing of wheels shall be taken as 1.8 m. A dynamic load allowance shall be considered as specified in Article [3.6.2](#).

4. Design Lane Load

The design lane load shall consist of a load of 20 kN/m uniformly distributed in the longitudinal direction.

Transversely, the design lane load shall be assumed to be uniformly distributed over 3 m width. The force effects from the design lane load shall not be subject to a dynamic load allowance.

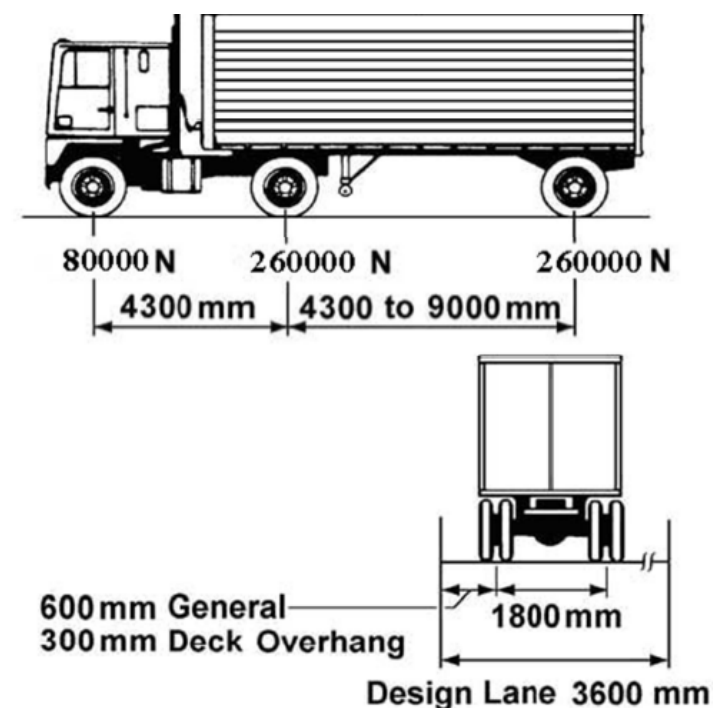


Figure 3.1: Characteristics of the Design Truck.

Design Vehicular Live Load as per other codes

United Arab Emirates:

- The manual of RTA and Abu Dhabi Roads and Bridges Manual Specify using AASHTO LRDF but with magnifying the vehicle live load with a factor of 1.50.

Sultanate of Oman:

- Using AASHTO LRDF but with magnifying the vehicle live load with a factor of 1.50.